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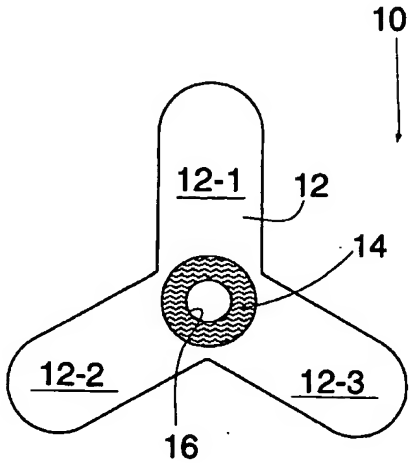
(54) Hollow bicomponent filaments and methods of making same

(57) Novel bicomponent fibers have a sheath domain and an core domain which is embedded entirely within, and thereby completely surrounded by, the polyamide domain. The core domain is annular and defines a longitudinally extending central void. The preferred bicomponent fibers have a sheath-core structure wherein the polyamide domain constitutes the sheath and a fiber-forming polyolefin polymer constitutes the core. The preferred trilobal bicomponent fibers will exhibit a modification ratio of between 2 to 4, an arm angle of between 7° to about 35°, and a total cross-sectional void area between about 3 and about 10 percent. Each lobe of the fiber may optionally contain a lobal void space which, if present, is preferably radially elongate in cross section.



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Description

The present invention relates generally to the field of synthetic fibers. More particularly, the present invention relates to synthetic bicomponent fibers having a sheath-core structure. In particularly preferred forms, the present invention is embodied in multi-lobal (e.g., trilobal) bicomponent fibers having a sheath domain entirely surrounding a longitudinally coextensive annular core domain which defines a longitudinally extending central void.

Polyamide has been utilized extensively as a synthetic fiber. While its structural and mechanical properties make it attractive for use in such capacities as carpeting, it is nonetheless relatively expensive. It would therefore be desirable to replace a portion of polyamide fibers with a core formed from a relatively lower cost non-polyamide material. However, replacing a portion of a 100% polyamide fiber with a core portion of a relatively less expensive non polyamide material may affect the mechanical properties of the fiber to an extent that it would no longer be useful in its intended end-use application (e.g., as a carpet fiber).

Furthermore, as evidenced by U.S. Patent No. 5,208,107 (the entire content of which is expressly incorporated hereinto by reference), hollow trilobal fibers have been proposed in the past so as to provide desirable "cover" and soil hiding properties. In essence, these conventional hollow trilobal filaments are characterized by a total cross-section void area of between about 3 and about 10 percent and have a single approximately axially extending central void.

It would therefore be highly desirable if sheath-core bicomponent filaments could be provided so as to minimize expenses associated with the higher cost sheath component. At the same time it would be desirable if such bicomponent filaments were provided with longitudinally extending central voids so as to provide the cover, luster and soil hiding characteristics associated conventional hollow trilobal filaments. It is towards fulfilling such needs that the present invention is directed.

Reference will hereinafter be made to the accompanying drawing FIGURE which is a schematic cross-sectional view of a representative hollow trilobal sheath-core bicomponent filament in accordance with the present invention.

As used herein and in the accompanying claims, the term "fiber" includes fibers of extreme or indefinite length (filaments) and fibers of short length (staple). The term "yarn" refers to a continuous strand or bundle of fibers.

The term "fiber forming" is meant to refer to at least partly oriented, partly crystalline, linear polymers which are capable of being formed into a fiber structure having a length at least 100 times its width and capable of being drawn without breakage at least about 10%.

The term "bicomponent fiber" is a fiber having at least two distinct cross-sectional domains respectively formed of different polymers. The term "bicomponent fiber" is thus intended to include concentric and eccentric sheath-core fiber structures, symmetric and asymmetric side by side fiber structures, island-in-sea fiber structures and pie wedge fiber structures. Preferred according to the present invention are concentric bicomponent sheath-core fiber structures having a polyamide sheath and a non-polyamide (e.g., polyolefin) core having the structures shown, for example, in U.S. Patent No. 5,244,614 (the entire content of which is expressly incorporated hereinto by reference). However, the present invention is equally applicable to other bicomponent fiber structures having other distinct longitudinally coextensive polymeric domains.

The term "linear polymer" is meant to encompass polymers having a straight chain structure wherein less than about 10% of the structural units have side chains and/or branches.

The preferred polyamides useful to form the sheath of the bicomponent fibers of this invention are those which are generically known by the term "nylon" and are long chain synthetic polymers containing amide (CO NH) linkages along the main polymer chain. Suitable melt spinnable, fiber forming polyamides for the sheath of the sheath-core bicomponent fibers according to this invention include those which are obtained by the polymerization of a lactam or an amino acid, or those polymers formed by the condensation of a diamine and a dicarboxylic acid. Typical polyamides useful in the present invention include nylon 6, nylon 6/6, nylon2 6/9, nylon 6/10, nylon 6T, nylon 6/12, nylon 11, nylon 12 and copolymers thereof or mixtures thereof. Polyamides can also be copolymers or nylon 6 or nylon 6/6 and nylon salt obtained by reacting a dicarboxylic acid component such as terephthalic acid, isophthalic acid, adipic acid or sebacic acid with a diamine such as hexamethylene diamine, methaxylene diamine, or 1,4-bisaminomethylcyclohexane. Preferred are poly ,-caprolactam (nylon 6) and polyhexamethylene adipamide (nylon 6/6). Most preferred is nylon 6.

As noted briefly above, the filaments according to this invention will most preferably include a longitudinally coextensive fiber-forming polyolefin core domain which is entirely surrounded by the sheath domain. Linear polypropylene and polyethylene are particularly preferred in this regard.

The core will represent less than about 30% by weight of the fibers according to this invention, with the sheath representing greater than about 70 wt.%. More preferably, the core will be less than about 25 wt.% of the fibers according to this invention, with the sheath being present in the fibers in an amount greater than about 75 wt.%. Thus, weight ratios of the sheath to the core in the fibers of this invention may range from about 2.3:1 to about 10:1, with a ratio of greater than about 3:1 being particularly preferred. Yarns formed from fibers according to this invention will exhibit desirable properties, such as less than about 75% heat-set shrinkage as

compared to yarns formed of 100% polyamide fibers.

The core may also be formed of an amorphous linear polymer which in and of itself is non fiber forming. Suitable amorphous polymers for use in the practice of this invention include polystyrene, polyisobutene and poly(methyl methacrylate). Preferably, the core is formed of amorphous polystyrene, with amorphous atactic polystyrene being particularly preferred.

The core may optionally include an inert particulate filler material dispersed therein. The filler material must have an average particle size which is sufficiently small to pass through the polymer filter of the spinnerette without affecting filter pressure. In this regard, particulate filler materials having a particle size in the range between about 0.1 to 5.0 μm, and preferably less than about 2.5 μm may be employed. When used, the filler material may be blended in a melt of the polyolefin core resin prior to being co-melt-spun with the polyamide sheath resin using conventional melt-blending equipment. Thus, for example, the filler material may be introduced via a side-arm associated with an extruder which melts the polyolefin and blends the introduced filler material therein upstream of the spinnerette pack.

Suitable particulate filler materials include calcium carbonate, alumina trihydrate, barium sulfate, calcium sulfate, mica, carbon black, graphite, kaolin, silica, talc and titanium dioxide. Calcium carbonate is particularly preferred.

The sheath-core fibers are spun using conventional fiber forming equipment. Thus, for example, separate melt flows of the sheath and core polymers may be fed to a conventional sheath-core spinnerette pack such as those described in U.S. Patent Nos. 5,162,074, 5,125,818, 5,344,297 and 5,445,884 (the entire content of each patent being incorporated expressly hereinto by reference) where the melt flows are combined to form extruded multi-lobal (e.g., tri-, tetra-, penta- or hexalobal) fibers having sheath and core structures. Preferably, the fibers have a tri-lobal structure with a modification ratio of at least about 1.4, more preferably between 2 and 4. In this regard, the term "modification ratio" means the ratio R_1/R_2, where R_2 is the radius of the largest circle that is wholly within a transverse cross section of the fiber, and R_1 is the radius of the circle that circumscribes the transverse cross-section.

Hollow trilobal bicomponent filaments in accordance with this invention will most preferably have an arm angle (i.e., the angle formed by extension of the sides of the individual lobes, or arms) of between about 7° to about 35°, more preferably between about 10° to about 35°. In addition, the filaments will most preferably include a single central void which will represent about 3 to about 10 percent, more preferably between about 5 to about 82 percent, of the total fiber volume measured including the volume of the void. Although a central symmetrical void is presently preferred, the filaments according to this invention may also include voids positioned in each of the filament lobes. If present, such lobe voids most preferably are radially elongate (e.g., generally elliptical) in cross-section.

The extruded fibers are quenched, for example with air, in order to solidify the fibers. The fibers may then be treated with a finish comprising a lubricating oil or mixture of oils and antistatic agents. The thus formed fibers are then combined to form a yarn bundle which is then wound on a suitable package.

In a subsequent step, the yarn is drawn and texturized to form a bulked continuous fiber (BCF) yarn suitable for tufting into carpets. A more preferred technique involves combining the extruded or as-spun fibers into a yarn, then drawing, texturizing and winding into a package all in a single step. This one-step method of making BCF is generally known in the art as spin-draw-texturing (SDT).

Nylon fibers for the purpose of carpet manufacturing have linear densities in the range of about 3 to about 75 denier/filament (dpf) (denier = weight in grams of a single fiber with a length of 9000 meters). A more preferred range for carpet fibers is from about 15 to 28 dpf.

The BCF yarns can go through various processing steps well known to those skilled in the art. For example, to produce carpets for floor covering applications, the BCF yarns are generally tufted into a pliable primary backing. Primary backing materials are generally selected form woven jute, woven polypropylene, cellulosic nonwovens, and nonwovens of nylon, polyester and polypropylene. The primary backing is then coated with a suitable latex material such as a conventional styrene-butadiene (SB) latex, vinylidene chloride polymer, or vinyl chloride-vinylidene chloride copolymers. It is common practice to use fillers such as calcium carbonate to reduce latex costs. The final step is to apply a secondary backing, generally a woven jute or woven synthetic such as polypropylene. Preferably, carpets for floor covering applications will include a woven polypropylene primary backing, a conventional SB latex formulation, and either a woven jute or woven polypropylene secondary carpet backing. The SB latex can include calcium carbonate filler and/or one or more the hydrate materials listed above.

While the discussion above has emphasized the fibers of this invention being formed into bulk continuous fibers for purposes of making carpet fibers, the fibers of this invention can be processed to form fibers for a variety of textile applications. In this regard, the fibers can be crimped or otherwise texturized and then chopped to form random lengths of staple fibers having individual fiber lengths varying from about 1 1/2 to about 8 inches. The fibers of this invention can be dyed or colored utilizing conventional fiber-coloring techniques. For example, the fibers of this invention may be subjected to an acid dye bath to achieve desired fiber coloration. Alternatively, the nylon sheath may be colored in the melt prior to fiber-formation (i.e., solution dyed) using conventional pigments for such purpose.

A further understanding of this invention will be

obtained from the following non-limiting Example which illustrates a specific embodiments thereof.

EXAMPLE

Nylon 6 (BASF Corporation Ultramid® BS-700F nylon) and polypropylene (Solvay Polymers Fortilene® 3808 polypropylene) are melt-extruded through spinnerette orifices as disclosed U.S. Patent No. 5,208,107 using the techniques described more fully in U.S. Patent No. 5,244,614 (incorporated fully hereinto by reference). The respective polymers are filtered and delivered to a pair of plates such as described in U.S. Patent No. 2,989,789 (incorporated fully hereinto by reference) except that there is no spinnerette capillary below the chamber where the materials are combined. Instead, this is done above a thin plate and a spinnerette backhole such that the sheath-core polymer flows are delivered to the spinnerette backholes. The polymer flows are delivered to the backholes of the spinnerette such that 75% by weight of nylon 6 is present in the sheath and 25% by weight polypropylene is in the core.

Fifty-eight (58) filaments are formed with each filament being cooled, drawn and textured in a continuous spin-draw apparatus (Rieter J0/10). The draw ratio is 2.8 and the winding speed is 2200 meters per minute. The resulting filament cross-section is depicted in the accompanying FIGURE. As is seen, the filament 10 is composed of a sheath domain 12 having three substantially equidistantly spaced-apart lobes 12-1, 12-2 and 12-3. The sheath domain 12 entirely surrounds a concentrically positioned, longitudinally coextensive annular core domain 14. The annular core domain 14 itself entirely surrounds and defines a longitudinally coextensive central void 16.

Claims

1. A multilobal synthetic bicomponent fiber comprising a sheath domain, and an annular core domain which is entirely surrounded by and longitudinally coextensive with said sheath domain, wherein said core domain defines a longitudinally extending central void.

2. The fiber of claim 1, wherein the sheath domain is a polyamide.

3. The fiber of claim 2, wherein the polyamide sheath domain is a nylon selected from the group consisting of nylon 6, nylon 6/6, nylon 6/9, nylon 6/10, nylon 6T, nylon 6/12, nylon 11, nylon 12, nylon 4,6 and copolymers thereof or mixtures thereof.

4. The fiber of claim 1, wherein the core domain is a fiber forming polyolefin.

5. The fiber of claim 4, wherein the polyolefin core domain is a linear polypropylene or polyethylene.

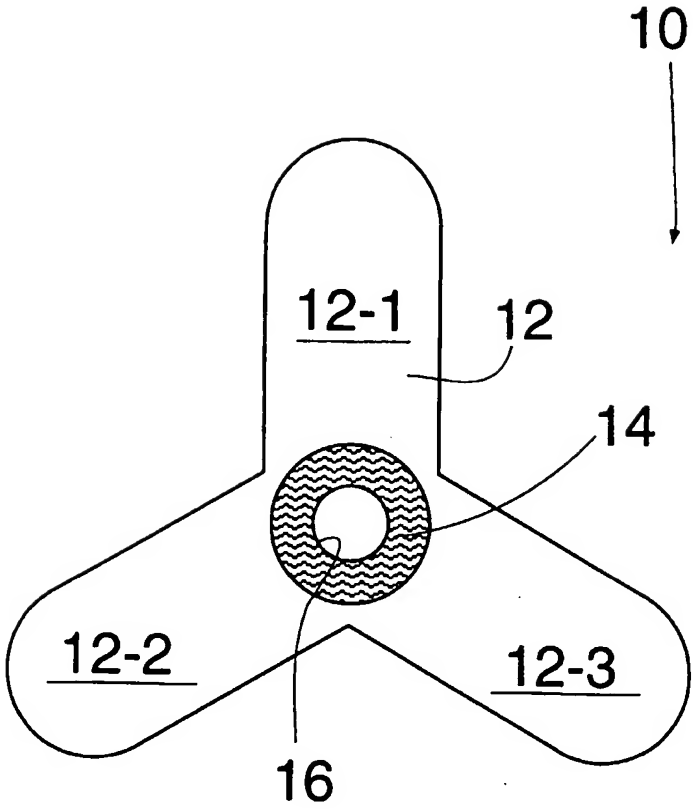
6. A yarn which includes a trilobal fiber according to any one of claims 1 to 5.

7. The fiber of any one of claims 1 to 5, in the form of a drawn and textured trilobal carpet fiber.

8. The fiber of any one of claims 1 to 5, in the form of continuous or staple fiber.

9. A carpet comprising a backing and a yarn tufted to said bakking, said yarn including a fiber of claim 7.

10. A method of making a hollow bicomponent multilobal sheath-core fiber comprising directing respective melt flows of sheath and core polymers to a spinnerette, forming a bicomponent fiber by extruding the incompatible polymers through orifices of the spinnerette to form a fiber having respective longitudinally coextensive sheath and core polymer domains corresponding to said sheath and core polymers, and simultaneously with said extruding of the sheath and core polymers, forming a longitudinally extending central void which is entirely surrounded by said core domain.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